

Detecting Water through Electric Impedance Measurements

Gregory Emery, Alexandre Ganchinho, Louis Mayencourt, Joseph Moerschell
HES-SO Valais-Wallis, Rawyl 47, 1950 Sion

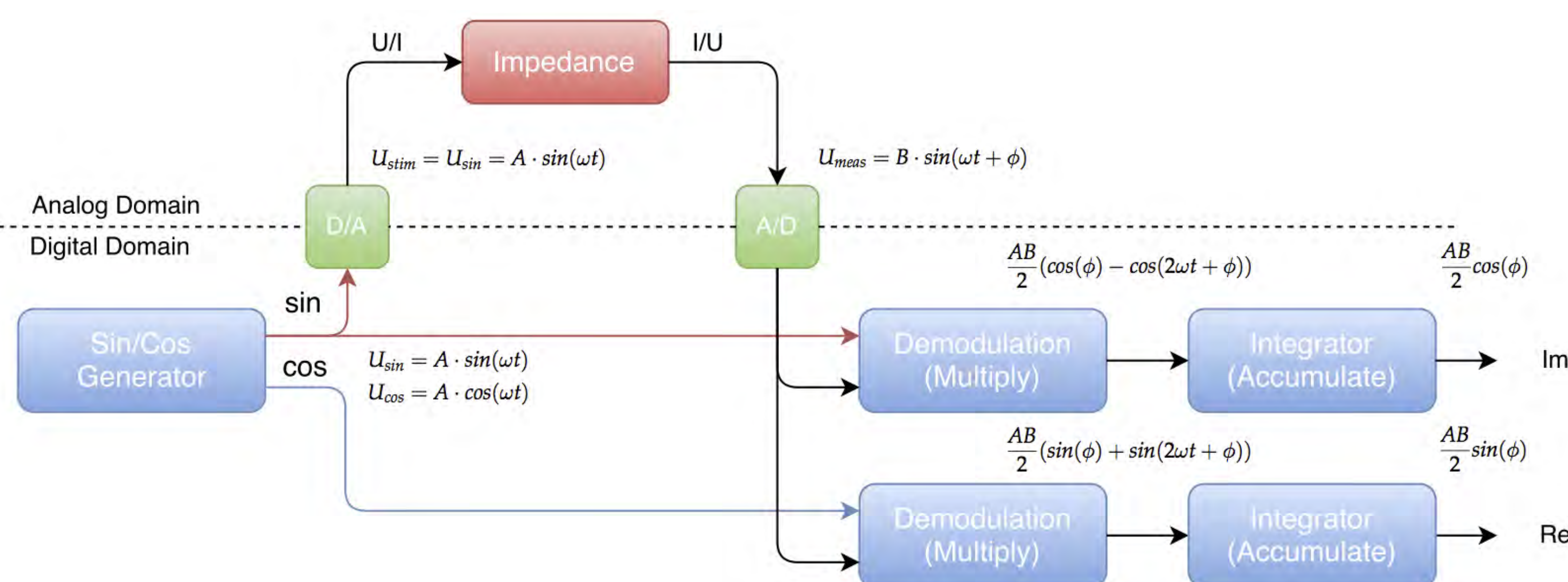
1. What is the problem ?

Sensors for deep water reservoir monitoring have to face several challenges:

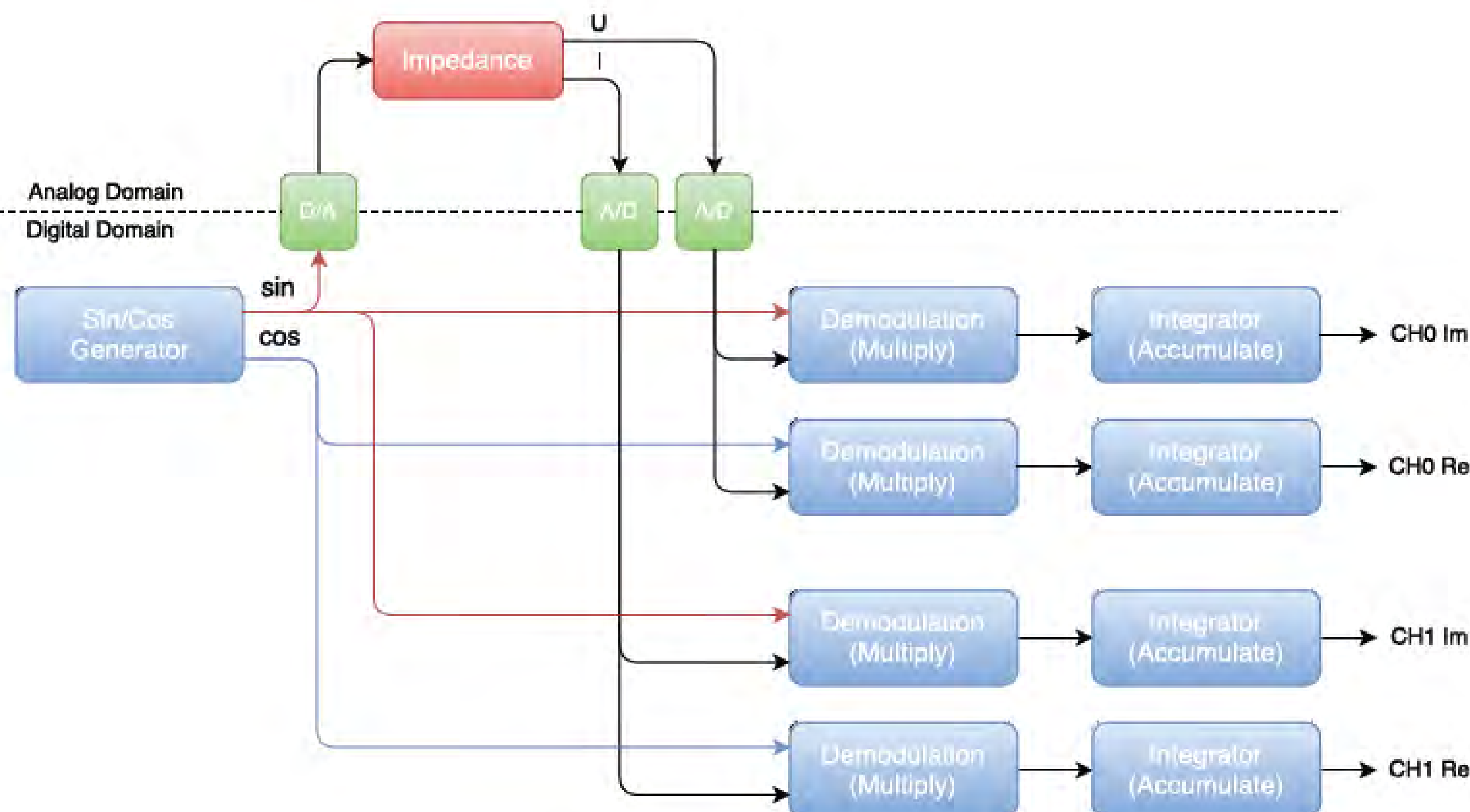
- important depth of aquifer location.
- need to detect small signals with high signal-to-noise-ratio.
- unknown absolute values of conductance of water.

2. Digital lock-in technique for impedance measurement

To reach high SNR, impedance measurement is based on a digital lock-in technique.

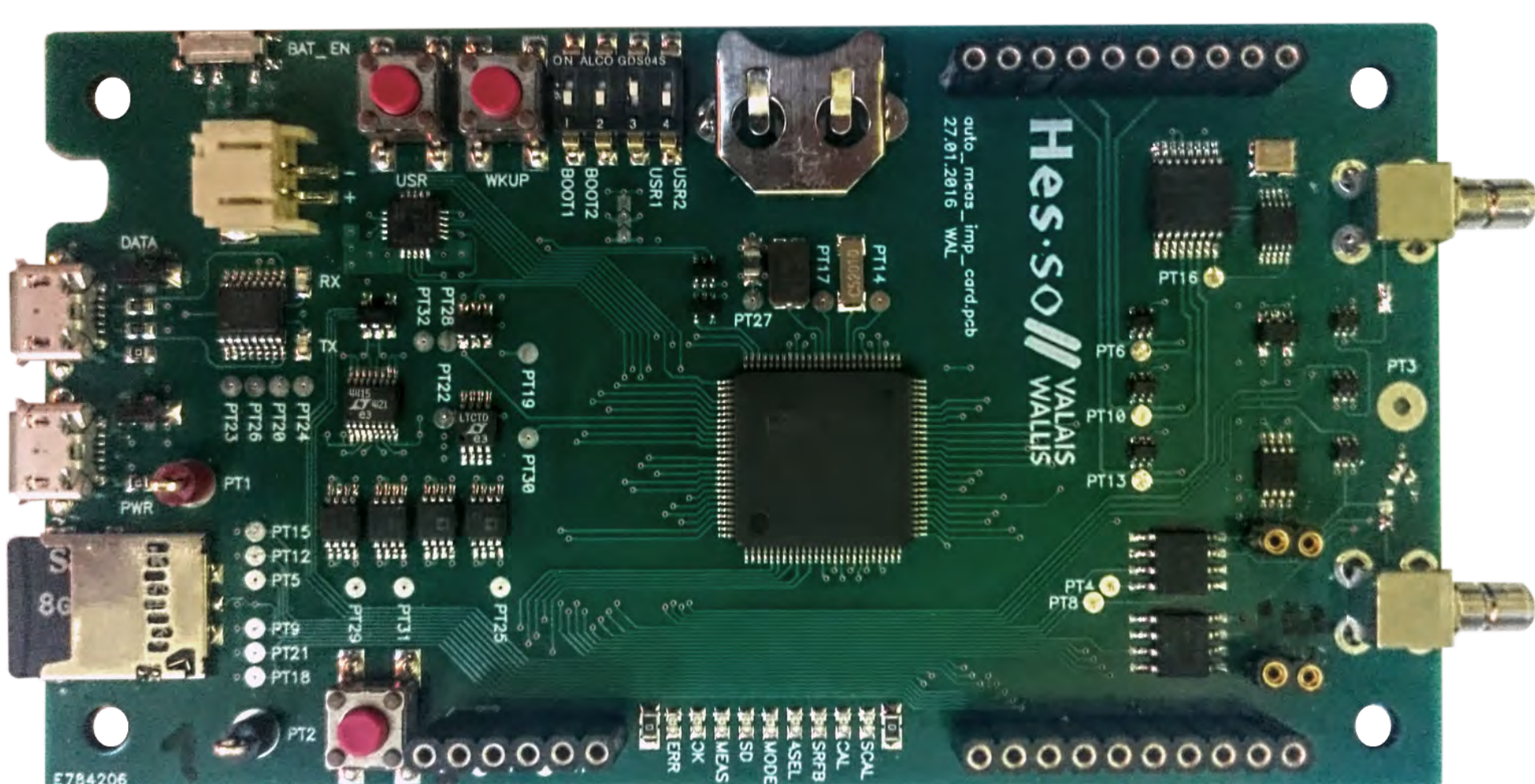


By sweeping the excitation frequency, impedance frequency spectra can be acquired. Current and voltage outputs can be digitized:



3. Low-to-medium bandwidth implementation

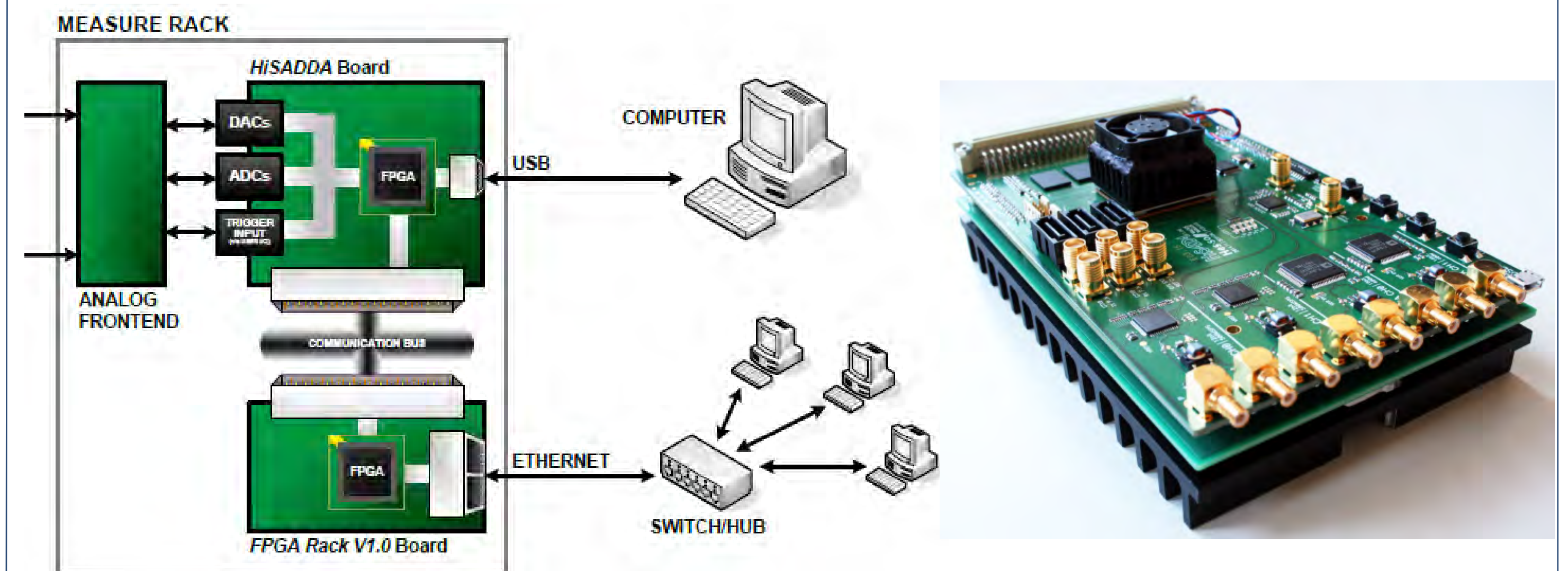
- Based on commercial single-chip implementation of lock-in technique, AD5933
- 100Hz to 100kHz excitation and measurement bandwidth



4. Large bandwidth implementation

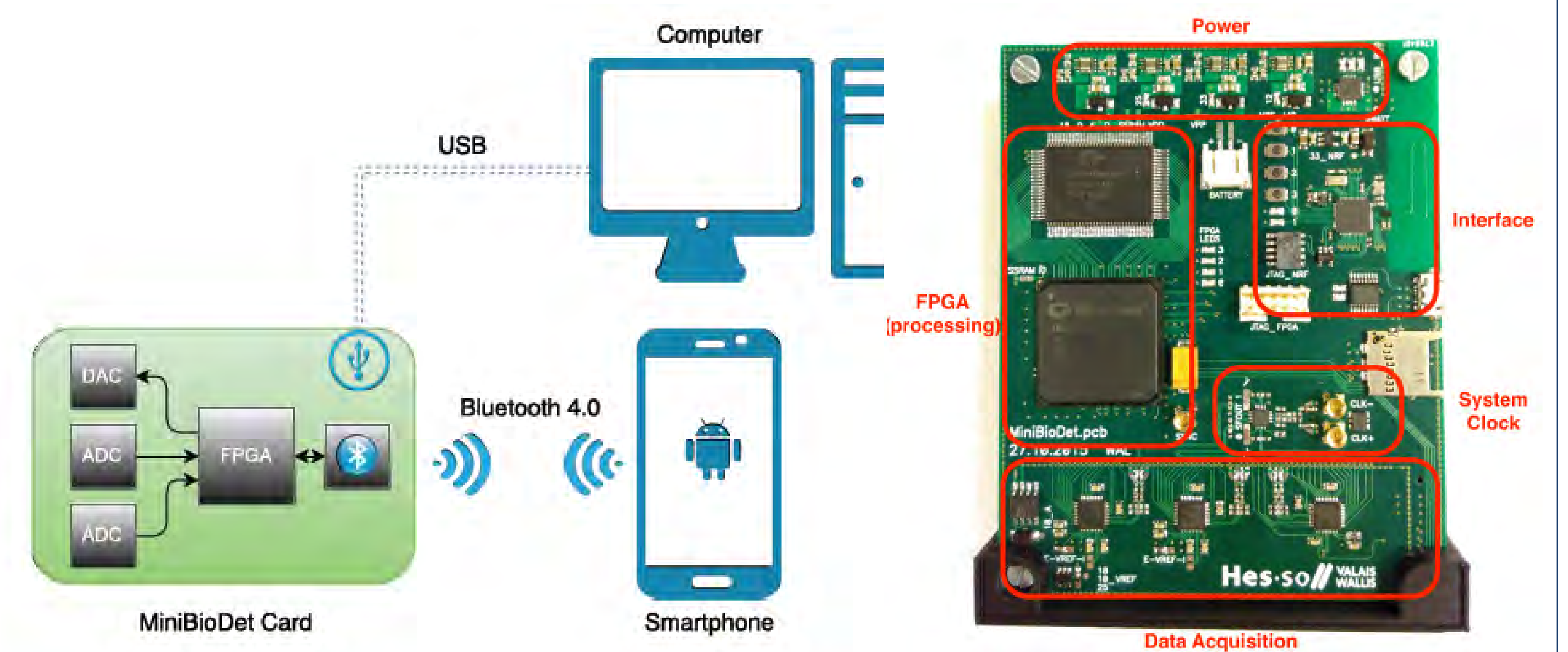
Large bandwidth lock-in detection can serve as well for impedance spectroscopy via contact electrodes, as for ground penetrating radar signal processing..

- mHz to 200MHz excitation and measurement bandwidth
- 12bit A/D and D/A conversion
- Direct digital sampling of excitation signal generation and acquisition
- Possibility to digitize high speed polarization processes as e.g. accompanying rock fracture



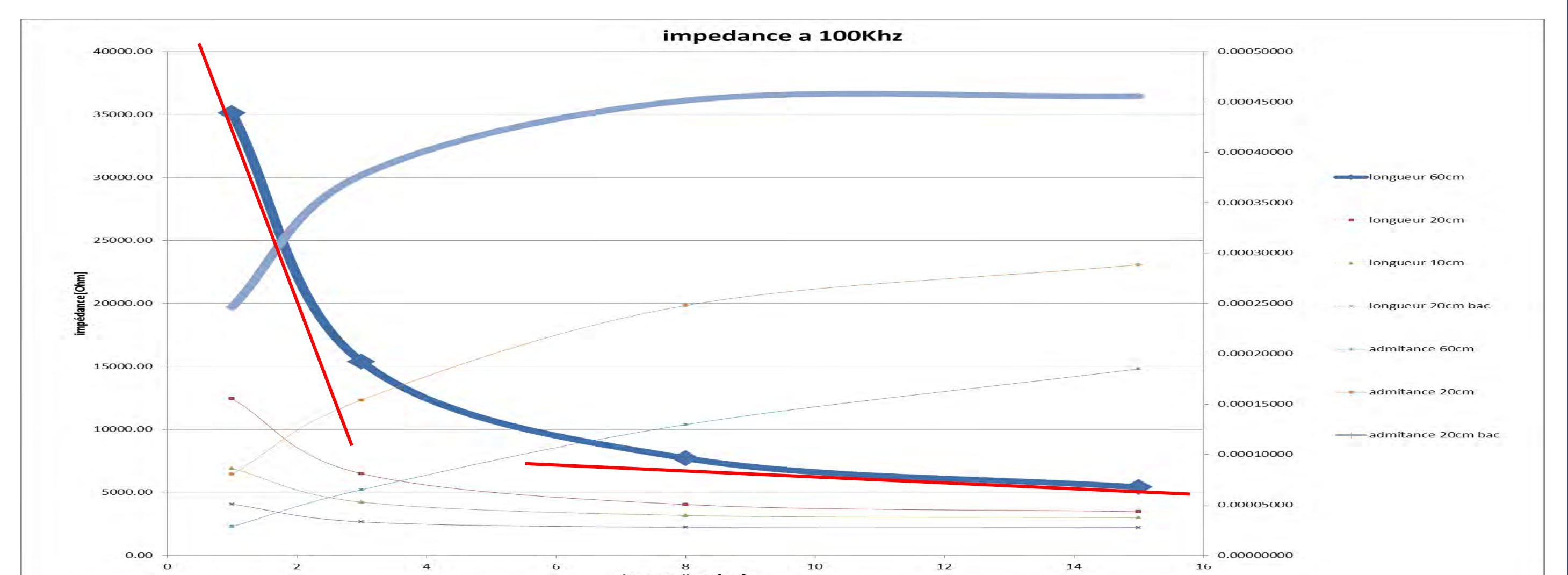
5. Battery powered lock-in amplifier

- For continuous monitoring applications at locations where public grid is not available, the impedance measurement equipment must be solar powered with battery buffering.
- 14bit D/A, 16bit A/D conversion, mHz to 20MHz excitation and measurement bandwidth
- Bluetooth communication with a smart phone as local user interface.



6. Small scale tests in water

- Digital excitation and synchronous demodulation.
- Frequency sweep range 1mHz...1MHz.
- Custom H/W and S/W development by HES-SO Valais.
- Different linearization possibilities depending on electrode spacing vs. depth and on the use of impedance or admittance



7. Small scale tests in snow

- Validation of measurement principle through a snow layer measurement
- Electrodes disposed on ground, facing upward
- Distance between electrodes not constant, allowing differential and common mode measurements
- Objective: estimation of snow layer thickness and characteristics

